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► To cite this version:

Benjamin Fleury, Nathalie Carrasco, Murthy S. Gudipati. Photochemistry of condensed species on Titan's aerosols analogues. European Planetary Science Congress 2015, Sep 2015, Nantes, France. pp.EPSC2015-814. insu-01208344

HAL Id: insu-01208344

<https://hal-insu.archives-ouvertes.fr/insu-01208344>

Submitted on 2 Oct 2015

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Photochemistry of condensed species on Titan's aerosols analogues

Benjamin Fleury (1), Nathalie Carrasco (1,2), Murthy S. Gudipati (3)

(1) Université Versailles St-Quentin ; Sorbonne Universités, UPMC Univ. Paris 06 ; CNRS/INSU, LATMOS-IPSL, 11 Boulevard d'Alembert, 78280 Guyancourt, France (2) Institut Universitaire de France, 103 Bvd St-Michel, 75005 Paris, France (3) Science Division, California Institute of Technology, 4800 Oak Grove Drive, Pasadena, CA, 91108 USA (benjamin.fleury@latmos.ipsl.fr)

Abstract

The formation of the aerosols of Titan starts in the upper layers of the atmosphere at about 1000 km. Then, they aggregate and sediment to the surface. Despite the intense work made on the comprehension of the aerosols formation, their chemical evolution during their sedimentation through the stratosphere and the troposphere remains unknown. In this work we investigate how the aerosols can interact with condensed species present in these atmospheric layers and chemically evolve when irradiated by UV solar photons.

1. Introduction

Titan, the largest satellite of Saturn, has a dense atmosphere made of molecular nitrogen (98 %) and methane (2 %) [1]. Dissociation and ionization of N_2 and CH_4 in the ionosphere of Titan at about 1000 km, by VUV solar photons and energetic particles from the Saturn's magnetosphere produce heavy organic molecules [2]. This chemistry initiates the formation of the brownish haze surrounding Titan. Then, the particles aggregate and sediment to the ground.

The measurement of the temperature profile in Titan's atmosphere by the HASI instrument onboard the Huygens probe shows a drop of temperature in the lower atmosphere with a minimum about 70 K at 44 km of altitude [3]. These low temperatures allow a possible condensation of photochemical products on the aerosols surface during their sedimentation through the stratosphere and the troposphere [4]. Different emission bands in the far infrared have been observed by the IRIS instrument of the Voyager spacecraft and by the CIRS instrument of the Cassini spacecraft and attributed to condensed species [5] [6].

If high-energy solar photons initiating the organic chemistry in the ionosphere of Titan's have been significantly absorbed at the altitude where species can condense, photons with longer wavelengths are still present at altitude as low as 100 km. A chemical evolution of aerosols can then be initiated by the reactivity of aerosols coated with condensed species and irradiated by solar photons in the UV-visible range.

Here we present a first experimental study of the aging processes of Titan's aerosols coated with condensed species and irradiated by UV-visible solar flux in the lower atmospheric layers of Titan.

2. Material and methods

To study this phenomenon, we irradiate condensed species coated on a blank sapphire window or coated on thin films of Titan's aerosols analogues, named tholins, with a UV laser.

The analogues are produced by subjecting a N_2 - CH_4 mixture to a radio-frequency discharge [7].

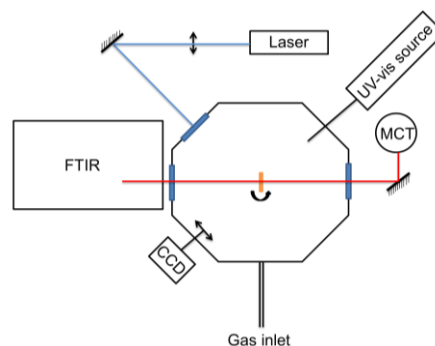


Figure 1: Scheme of the Acquabella experimental setup at the JPL's Titan Organic Aerosol Spectroscopy and chemisTry (TOAST) laboratory.

A blank sapphire window or a tholins sample is mounted in the Acquabella experiment [8]. C_2H_2 is deposited at 50 K to form an ice film on the top of the tholins sample. C_2H_2 is one of the most abundant species in the atmosphere of Titan's with a mixing ratio about 2 ppm_v as measured by the CIRS instrument at 120 km [9] and solid C_2H_2 has been observed in Titan's stratosphere [10].

The acetylene consumption during the irradiation is monitored using absorption infrared spectroscopy. The evolution of the tholins sample, after the sublimation of the remaining ice, is monitored by absorption infrared spectroscopy.

3. Results

We conducted a series of experiments by depositing a thin layer of acetylene ice over the tholins film and subjected these samples to various solar spectra wavelengths using a tunable laser system. We found that while at longer wavelengths no significant chemistry was noticeable, but at shorter wavelengths, particularly 355 nm a significant amount of acetylene was depleted, indicating chemical bonding of acetylene to the tholins polymer.

Controlled experiments showed that a higher consumption of C_2H_2 coated on a tholins sample occurred compared to the irradiation of C_2H_2 ice film alone. Further experimental results and analysis of the data will be presented.

Acknowledgements

This research was carried out partly in France and partly in JPL. B. F. thanks the Région Île-de-France for his financial support (DIM ACAV thesis grant). The JPL (Jet Propulsion Laboratory, California Institute of Technology) part was under a contract with the National Aeronautics and Space Administration and was funded by NASA Astrobiology Grant.

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